

MACROLIDE ANTIBIOTIC SUBSTANCES
FERMENTATION OF STREPTOMYCES MICROORGANISM IN
PRESENCE OF FATTY ACID(S) OR SALTS, ESTERS OR
AMIDES

BASIC



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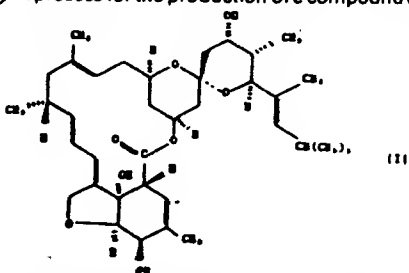
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(84) Process for the production of macrolide compounds.

(87) A process for the production of a compound of formula
(I)



which comprises cultivating a microorganism of the genus *Streptomyces* capable of producing the compound of formula (I) in the presence of one or more fatty acids and/or salts, esters and amides of these acids, whereby the compound of formula (I) is produced, and if desired isolating the said compound. The fatty acid increases the yield of the formula (I) compound and is preferably isobutyric or valeric acid.

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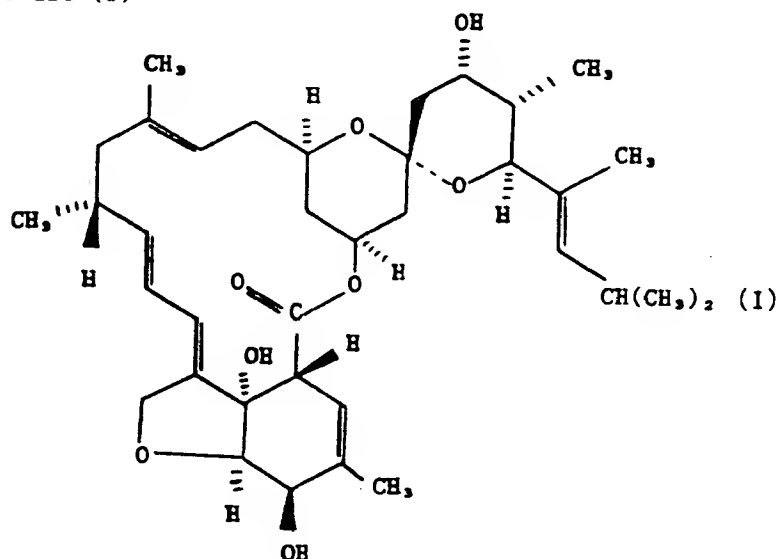
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This invention relates to a new process for the production of an antibiotic compound. In particular it relates to a process for the production of an antibiotic compound by cultivation of Streptomyces microorganisms.

5 United Kingdom Patent Specification No. 2166436 and European Patent Specification No. 170006 describe the production of a class of compounds, which we have designated Antibiotics S541. Antibiotics S541 substances have antibiotic and, in particular, anti-endoparasitic, anti-ectoparasitic, anti-fungal, insecticidal, 10 nematocidal and acaricidal activity and are of special interest for use in agriculture, horticulture, and animal and human health. Antibiotics S541 substances are also useful as intermediates in the preparation of other compounds having the antibiotic activity referred to above.

15 An Antibiotics S541 compound of special interest is the compound of formula (I)



25 UK Patent Specification No 2166436 and European Patent Specification No 170006 describe the production of the compound of formula (I) and other Antibiotics S541 compounds by cultivation of microorganisms belonging to the genus Streptomyces. Under the normal 35 cultivation conditions described in these patent applications the

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Streptomyces microorganisms produce a mixture of different Antibiotics S541 compounds. This gives rise to two problems when a particular Antibiotics S541 compound is required. Firstly, the titre of the desired Antibiotics S541 compound is reduced and, secondly, the isolation and separation of the desired compound is difficult from a mixture of related compounds.

We have now found that it is possible to cultivate an Antibiotics S541 producing Streptomyces strain in a manner such that the microorganism produces the compound of formula (I) above in a higher proportion relative to other Antibiotics S541 compounds than in the case when the microorganism is fermented under normal fermentation conditions. In general, the improvement is achieved by cultivating the Streptomyces microorganism in the presence of fatty acids and salts, esters and amides thereof. In this way, the titre of the compound of formula (I) is increased and the isolation and separation of the compound of formula (I) is made easier, and, advantageously, higher yields of the compound are thus obtained.

Thus, according to one aspect of the invention we provide a process for the production of a compound of formula (I) which comprises cultivating a microorganism of the genus Streptomyces capable of producing the compound of formula (I) in the presence of one or more fatty acids and/or salts, esters and amides of these acids, whereby the compound of formula (I) is produced, and if desired isolating the said compound.

Microorganisms capable of producing the compound of formula (I) may readily be identified using a convenient small scale test employing the nematode Caenorhabditis elegans, for example by adding a test sample [obtained from fermentation of the microorganism] to a suspension of the nematode and examining the consequent effect on nematode viability and by analytical high performance liquid chromatography on the test sample.

The microorganism will preferably be of the species Streptomyces thermoarchaensis, or Streptomyces cyaneogriseus noncyanogenus, in particular Streptomyces thermoarchaensis NCIB 12015 (deposited 10 September 1984), Streptomyces thermoarchaensis NCIB 12111, 12112, 12113 and 12114 (all deposited 26 June 1985) and Streptomyces

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Cyanogriissus noncyanogenus NRRL 15773 (deposited 3rd May 1984) and mutants of all these strains.

Mutants of the above strains may arise spontaneously or may be produced by a variety of methods including those outlined in Techniques for the Development of Micro-organisms by H.I. Adler in 'Radiation and Radioisotopes for Industrial Microorganisms', Proceedings of the Symposium, Vienna 1973, p241, International Atomic Energy Authority. Such methods include ionising radiation, chemical methods e.g. treatment with N-methyl-N'-nitro-N-nitrosoguanidine (NTG); heat; genetic techniques, such as recombination, transduction, transformation, lysogenisation and lysogenic conversion, and selective techniques for spontaneous mutants and mutants of all these strains.

Fatty acids which may be used according to the process of the present invention will include any fatty acids which provide the compound of formula (I) in a higher proportion relative to other Antibiotics S541 compounds than in the case when the fermentation is carried out under normal condition. Fatty acids capable of effecting an improvement in the proportion of the compound of formula (I) relative to other Antibiotics S541 compounds may readily be identified using a convenient small scale fermentation and examining the effect of adding different fatty acids by analytical high performance liquid chromatography of the test sample. Examples of fatty acids which may be used according to the process of the present invention include organic acids containing up to ten carbon atoms, eg three to eight carbon atoms.

Particularly suitable fatty acids include isobutyric acid and valeric acid.

Thus, in a preferred aspect of the present invention we provide a process for the preparation of a compound of formula (I) which comprises cultivating a microorganism of the genus Streptomyces capable of producing the compound of formula (I) in the presence of one or more compounds selected from isobutyric acid, valeric acid and the salts, esters and amides of these acids, whereby the compound of formula (I) is produced, and if desired isolating the said compound.

Examples of suitable salts of the fatty acids include alkali metal salts such as potassium or sodium salts. Suitable esters include alkyl esters e.g. C₁₋₄ alkyl esters such as methyl or ethyl esters.

We have found it advantageous to carry out the process of the invention in the presence of two fatty acids or salts thereof. Use of both acids or their salts in the same fermentation produces the compound of formula (I) in a desirably high ratio relative to other Antibiotics S541 compounds. Thus, in a particularly preferred aspect of the invention we provide a process for the production of a compound of formula (I) which comprises cultivating a microorganism of the genus Streptomyces capable of producing the compound of formula (I) in the presence of two fatty acids or salts thereof, whereby the compound of formula (I) is produced, and if desired isolating said compound therefrom.

We have found that it is especially advantageous to carry out the process of the invention in the presence of isobutyric acid and valeric acid or salts thereof. Use of both acids or their salts in the same fermentation produces the compound of formula (I) in a desirably high ratio relative to other Antibiotics S541 compounds. Thus, in a particular aspect of the invention we provide a process for the production of a compound of formula (I) which comprises cultivating a microorganism of the genus Streptomyces capable of producing the compound of formula (I) in the presence of isobutyric acid or a salt thereof and valeric acid or a salt thereof, whereby the compound of formula (I) is produced, and if desired isolating said compound therefrom.

Where more than one fatty acid substance is added to the fermentation the fatty acid substances may be added together in a set ratio or, preferably, independently of each other. The ratio may be changed during the cultivation as desired either by keeping the quantity of one substance constant and changing the quantity of the other or by altering the quantities of both substances. The exact quantities will need to be empirically determined to meet the requirements of the cultivation. The culture medium used for cultivating the microorganism producing the compound of formula (I) is that which would normally be used for the production of the said compound, but with the fatty acid(s) or salts, esters or amides thereof added.

In general the fatty acid substance(s) may be added at any time during the cultivation of the microorganism. We have found it preferable however to begin adding the substance(s) when the pH of the culture medium begins to change away from the natural pH of around 5.5 to 7.5 and/or the microorganism begins to produce the compound of formula (I). This may generally happen at around 18 hours into the cultivation. At this point the fatty acid substance(s) is/are added to control the pH at the desired level (i.e. around pH 5.5 to 7.5, e.g. pH 7.2 to 7.4). The same or different fatty acid substance(s) may then be added throughout the rest of the fermentation to maintain the pH of the desired level. Alternatively, the fatty acid substance(s) may be added at a fixed rate throughout the rest of the fermentation with an aqueous acid (e.g. sulphuric acid) or a base (e.g. sodium hydroxide) added as appropriate to maintain the pH at the desired level. The quantity of fatty acid substance(s) required will vary over a wide range depending on the nature of the culture medium and Streptomyces strain used and generally needs to be empirically determined to meet the requirements of each cultivation. It is also important to determine empirically whether it is necessary to have an accumulation of the fatty acid substance(s) in the medium. However, we have found that it may be preferable to avoid adding the fatty acid substance(s) in a quantity which allows accumulation to take place when the fermentation is carried out using a microorganism of the species Streptomyces thermoarchaensis or Streptomyces cyaneogriseus noncyanogenus.

In the process according to the invention, the culture medium will in general contain other assimilable sources of carbon, nitrogen and mineral salts in addition to the fatty acid substance(s) discussed above. Suitable sources of carbon, nitrogen and mineral salts are discussed in UK Patent Specification No 2166436 and European Patent Specification No 170006.

Cultivation of the Streptomyces organism will generally be effected according to the methods described in UK Patent Specification No. 2166436 and, if desired, the compound of formula (I) may be separated from the whole fermentation by conventional isolation and separation techniques as described in the aforementioned UK and

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European Patent Specifications. UK Patent Specification No 2166436 and European Patent Specification No 170006 also describe suitable methods for purifying the compound of formula (I).

The following Example illustrates the invention. In the following examples 1 means litre.

Example 1

Spores of Streptomyces thermoarchaealis NCIB 12015 were inoculated onto agar slants made up of the following ingredients:

	<u>g/L-1</u>
Yeast extract (Oxoid L21)	0.5
Malt extract (Oxoid L39)	30.0
Mycological Peptone (Oxoid L40)	5.0
Agar No. 3 (Oxoid L13)	15.0

Distilled water to 1L, pH approximately 5.4.

and incubated at 28°C for 10 days. The mature slant was then covered with a 20% glycerol solution (6ml) and scraped with a sterile tool to loosen the spores and mycelium. 0.4ml of the resulting spore suspension was used to inoculate a 250ml Erlenmeyer flask containing Medium A:

<u>Medium A</u>	<u>g/L-1</u>
Glucose	2.5
Malt Dextrin MD 30E	25.0
Arkasoy 50	12.5
Molasses	1.5
K ₂ HPO ₄	0.125
CaCO ₃	1.25
3-(N-Morpholino) propane-sulphonic acid (MOPS)	21.0

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Distilled water to 1L, pH adjusted to pH 6.5 before autoclaving.

The culture was incubated at 28°C for 2 days on a rotary shaker operated at 250rpm with a 50mm diameter orbital motion. 2% (v/v) portions of the 2 day developed inoculum were used to inoculate further 250ml Erlenmeyer flasks containing Medium A (50ml) and incubated as previously described.

80ml of the bulked shake flask developed inoculum was used to inoculate a fermenter (7L) containing Medium B (4L):

<u>Medium B</u>		<u>g/L</u>
	Glucose	3.75
	Malt Dextrin MD 30E	37.5
	Arkasoy 50	18.8
	Molasaes	2.25
	K ₂ HPO ₄	0.188
	CaCO ₃	1.88

pH adjusted to pH 6.5 before autoclaving.

The fermentations were controlled to a temperature of 35°C. The culture was agitated at 500 rev/min and aerated at 3L/min. The pH was controlled to prevent the pH rising above pH 7.2-7.4 either by addition of:

- (i) 10% H₂SO₄ (according to the method described in Example 5 in UK Patent Specification No 2166436)
80ml 10% H₂SO₄ used for pH control and harvested at 114h.
- (ii) 50/50 valeric acid/isobutyric acid
110 mls 50/50 valeric acid/isobutyric acid was used for pH control from 18-138h
i.e. an average of 2.75g valeric acid was used/L/day
Similarly an average of 2.75g isobutyric acid was used/L/day.
- (iii) 40/60 valeric acid/isobutyric acid
115ml 40/60 valeric acid/isobutyric acid used for pH control from 18-138 h

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i.e. an average of 2.3g valeric acid was used/L/day
 i.e. an average of 3.45g isobutyric acid was used/L/day.

- (iv) 30/70 valeric acid/isobutyric acid
 125ml 30/70 valeric acid/isobutyric acid used for pH control
 from 18-138h ie an average of 1.875g valeric acid was
 used/L/day
 ie an average of 4.375g isobutyric acid was used/L/day

- (v) 60/40 valeric acid/isobutyric acid
 115ml 60/40 valeric acid/isobutyric acid used for pH control
 from 18-138h
 ie an average of 3.45g valeric acid was used/L/day
 ie an average of 2.3g isobutyric acid was used/L/day

The fermentations were harvested at 138h unless otherwise stated and
 titres of the compound of formula (I) determined as follows:

20	Acid for pH control	Compound of formula (I) mg/L	% Total Antibiotics 5541 Compounds
(i)	H_2SO_4 = normal pH control	284	46
25	(ii) 50/50 valeric acid/ isobutyric acid	474	55
(iii)	40/60 valeric acid/ isobutyric acid	504	64
30	(iv) 30/70 valeric acid/ isobutyric acid	236	78
35	(v) 60/40 valeric acid/ isobutyric acid	348	49

Example 2

The fermentation of Example 1 was repeated but using Medium C (4L) in place of Medium B.

5	<u>Medium C</u>	<u>g/L⁻¹</u>
	Meritose	45.0
	Arkasoy 50	18.8
	Molasses	2.2
10	K ₂ HPO ₄	0.18
	CaCO ₃	1.8
	Silicone 1520	0.625

15 Distilled water to 1L, pH adjusted to 6.5 with aqueous H₂SO₄ before autoclaving.

The fermentations were controlled to a temperature of 35°. The culture was agitated at 500 rev/min and aerated at 3L/min. The fermentations were also subjected to the following conditions:

20 (i) 10% H₂SO₄ added to prevent the pH rising above pH 7.2-7.4. 100ml 10% H₂SO₄ used for pH control. The fermentation was harvested at 138h.

25 (ii) Isobutyric acid added at an average rate of 2.63g/L/day from 24-162h with valeric acid or 10% NaOH added as appropriate to control the pH to pH 7.2-7.4. An average of 2.17g Valeric acid was used/L/day and a total of 2.1g NaOH was used.

30 (iii) Isobutyric acid added at an average rate of 3.71g/L/day from 24-162h with valeric acid or 10% NaOH added as appropriate to control the pH to pH 7.2-7.4. An average of 4.46g valeric acid was used/L/day and a total of 2.6g NaOH was used.

(iv) Isobutyric acid added at an average rate of 4.38g/L/day from 24-162h with valeric acid or NaOH added as appropriate to control the pH to pH 7.2-7.4. An average of 3.13g valeric acid was used/L/day and a total of 3.0g NaOH was used.

35 The fermentations were harvested at 162h unless otherwise stated and titres of the compound of formula (I) determined as follows:

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Acid	Compound of formula (I) mg/L	% Total Antibiotics 5541 compounds
(i) H_2SO_4 =normal pH control	467	46
(ii) an average of 2.63g/L/day isobutyric acid	804	69
(iii) an average of 3.71g/L/day isobutyric acid	714	58
(iv) an average of 4.38g/L/day isobutyric acid	921	78

Example 3

A liquid nitrogen strain of Streptomyces cyaneogriseus noncyanogenus NRRL 15773 was used to inoculate a 250ml shake flask containing Medium A (50ml) and incubated at 28°C for 2 days on a rotary shaker operated at 250rpm with a 2" diameter orbital throw. 1ml portions of this 2 day developed inoculum were used to inoculate further 250ml shake flasks containing Medium A (50ml) and incubated as previously described.

80ml of the bulked shake flask developed inoculum was used to inoculate a fermenter (7L) containing Medium C (4L).

The fermentation was controlled to a temperature of 30°C. The culture was agitated at 500 rev/min and aerated at 3L/min. The pH was controlled down to pH 7.4 by addition of 50/50 valeric acid/isobutyric acid from 18-162h into the fermentation.

The fermentation was harvested at 162h to give 250 mg/L of the compound of formula (I) corresponding to 84% total of the Antibiotics 5541 compounds produced.

Example 4

The inoculum stages of Example 1 using Medium A were followed. 80ml of the bulked shake flask developed inoculum was used to inoculate a fermenter (7L) containing Medium D (4L).

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<u>Medium D</u>	<u>g⁻¹</u>
Glucose	2.5
Malt Dextrin MD 30E	25.0
Arkasoy 50	12.5
Molasses	1.5
K ₂ HPO ₄	0.125
CaCO ₃	1.25

Distilled water to 4L, pH adjusted to 6.5 before autoclaving.
The fermentation was carried out for 24h at a temperature of 28°C with the culture agitated (500 rev/min) and aerated (3L/min).

800ml of this 24h developed inoculum was used to inoculate a fermenter (70L) containing Medium D (40L). The fermentation was carried out for 24h at a temperature of 28°C with the culture agitated (550 rev/min) and aerated (30L/min).

800ml of this 24h developed inoculum was used to inoculate Medium B (40L) in a fermenter (70L).

The fermentation was controlled to a temperature of 34°C. The culture was agitated (550 rev/min) and aerated (40L/min) and 50/50 valeric acid/isobutyric acid was added at an average rate of 10ml/h from 21h to 117h with 10% H₂SO₄ and 10% NaOH added as appropriate to control the pH to around pH 7.4.

The fermentation was harvested at 117h to give 944mg/L of the compound of formula (I) corresponding to 79% total of the Antibiotic S541 compounds produced.

Example 5

The inoculum stages of Example 1 using Medium A were followed. 80ml of the bulked shake flask developed inoculum was used to inoculate a fermenter (7L) containing Medium D (4L). The fermentation was carried out for 24h at 28°C with the culture agitated (500 rev/min) and aerated (4L/min).

800ml of this 24h developed inoculum was used to inoculate a fermenter (70L) containing Medium C (40L).

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The fermentation temperature was controlled to 34°C. The fermenter was agitated (550 rev/min) and aerated (40L/min) and the pH controlled to around pH 7.3 by adding either (1) 80/20 valeric acid/isobutyric acid at an average rate of 6.67g/L/day from 18 to 162h or (2) 75/25 valeric acid/isobutyric acid added at an average rate of 6.34 g/L/day from 18 to 186h.

The fermentations were harvested at 162h and 186h respectively to give either (1) 510 mg/L of the compound of formula (I) corresponding to 61% total of the Antibiotics S541 compounds produced or (2) 516 mg/L of the compound of formula (I) corresponding to 72% total of the Antibiotics S541 compounds produced.

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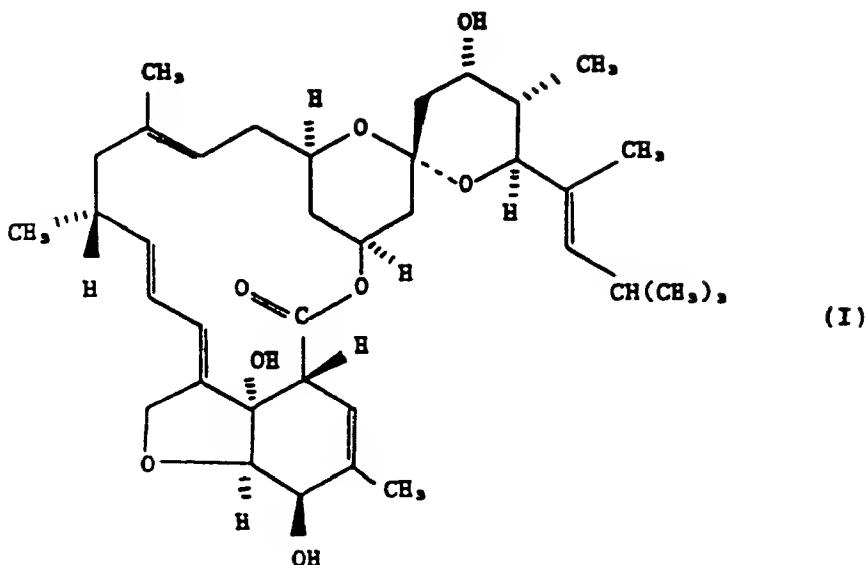
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CLAIMS:

1. A process for the production of a compound of formula (I)



which comprises cultivating a microorganism of the genus Streptomyces capable of producing the compound of formula (I) in the presence of one or more fatty acids and/or salts, esters and amides of these acids, whereby the compound of formula (I) is produced, and if desired isolating the said compound.

2. A process according to claim 1 in which the fatty acid is isobutyric or valeric acid.
3. A process according to claim 1 in which the microorganism is cultivated in the presence of isobutyric acid (or a salt thereof) and valeric acid (or a salt thereof).

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4. A process according to claim 1 in which the fatty acid is added to adjust the pH of the cultivation medium to 5.5 - 7.5 and thereafter the pH is maintained in this range.

5. A process according to claim 1 in which the microorganism is a member of the species Streptomyces thermoarchaensis, or Streptomyces cyaneogriseus noncyanogenus.

6. A process according to claim 1 in which the microorganism is Streptomyces thermoarchaensis NCIB 12015, 12111, 12112, 12113 or 12114 or Streptomyces cyaneogriseus noncyanogenus NRRL 15773, or a mutant of any of these strains.



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EUROPEAN SEARCH REPORT

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Application number

EP 87 30 2099

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 4)
A, D	EP-A-0 017 006 (AMERICAN CYANAMID CO.) * Pages 1-9 *	1	C 07 D 493/22 C 12 P 17/08 (C 07 D 493/22 C 07 D 313:00 C 07 D 311:00 C 07 D 311:00 C 07 D 307:00) (C 12 P 17/00 C 12 R 1:465)
A, D	FR-A-2 570 390 (GLAXO) * Pages 50-62 * -----	1	
The present search report has been drawn up for all claims			<div style="text-align: center; border: 1px solid black; padding: 2px; margin-bottom: 5px;">TECHNICAL FIELDS SEARCHED (Int. Cl. 4)</div> <div style="padding: 5px;">C 07 D 493/00 C 12 P 17/00</div>
Place of search THE HAGUE		Date of completion of the search 02-06-1987	Examiner VERHULST W.
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